Urban Services Planning
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Lecture 30
Composting Part III

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Welcome back in lecture 30, we will be talking about the third part of composting. And here we will talk about the different techniques of composting. So, the concepts that we will cover in this lecture are on windrow composting, aerated static pile composting, passive aeration methods, in vehicle composting, vermicomposting, and also we will talk about yard waste composting.

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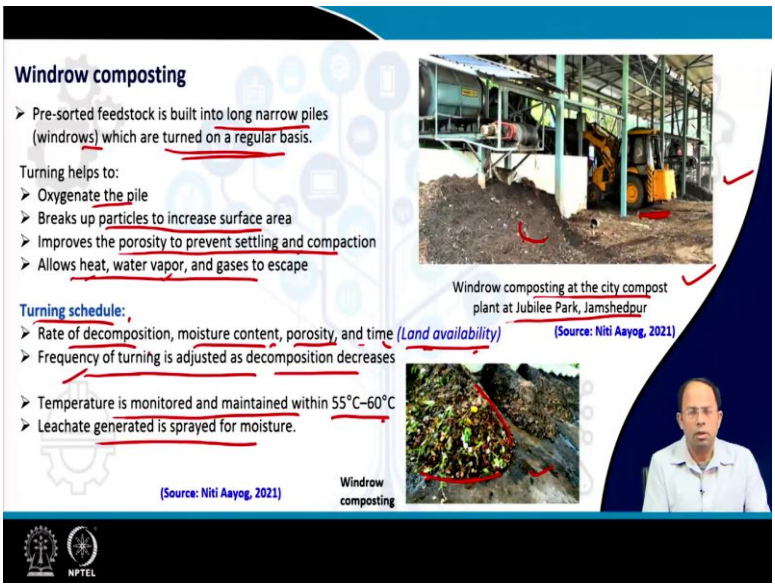

So, first we talk about windrow composting. Pre-sorted feedstock is built into long narrow piles or windows which are turned on a regular basis. So, we have learnt about windrows in our earlier lectures as well. So, this is the image we have used shown you earlier as well. So, this is how a windrow looks like, it is a pile of garbage, but before it is live like that, we have to you know, make sure that some amount of sorting is being done, so, that the final product contains mostly organic matter.

So, we have to turn the windrows on a regular basis, as you can see that we use different kinds of machines for that like this kind of bucket loaders could be utilized. So, the bucket loaders can leave the garbage, leave the unit compost or that organic matter and then can make it into this form of a pile or there is something called a turning machine which I will show you a image of that. So, those kinds of machines could be also utilized which can keep on mixing the garbage piles as well.

So, this is how a windrow composting is done at the city compost plant at Jubilee Park in Jamshedpur. This is how the composting plant looks like. Now, why is turning done? Now, turning helps to oxygenate the pipe this we have learnt earlier breaks up the particles to increase surface area, improves the porosity to prevent settling and compaction, allows heat water vapor and gases to escape. So, it prevents too much of heat build-up allows water vapor to escape from your a CH_4 to escape CO_2 to escape as well.

Porosity it is improved porosity because you know it gradually compost gearstick or decomposes and it gradually settles and you know it becomes more and more compact. So, of course, when you break it, it becomes more porous, more oxygen mixes that includes the you know the decomposition process and so on. Now, the turning schedule how much I should turn? Depends on the rate of decomposition, it depends again on the weather, the climate and so on, moisture content of waste, porosity of waste and the time you have in hand. So, if you have less time in that case, you have to turn more as we have learnt earlier that is the turning schedule, when it is increased automatically the time for composting decreases.

Now, time is very very related with land availability, if I have got less land that means I can stored the garbage for lesser amount of time every day garbage comes in. So, if I have got less time, less area in that case, I have to complete the process in a much shorter period. So that is why time and land area is very very related.

So, frequency of turning is adjusted as decomposition decreases. So, gradually the decomposition process lowers and accordingly we have to also change the turning frequency.

So, that was again the turning frequency is not fixed it has to be adjusted. Temperature is monitored and maintained, so sometimes we have discussed this earlier as well. If the temperature goes beyond 70 degree, it is a you know every all pathogens will be killed and all so the decomposition will alter.

So at least we will try to maintain our 55 to 60 degree for a certain 3 weeks or 2 weeks period. That is good enough for production of compost, leachate generated is collected sometime it is sprayed back which gives added moisture to the compost. So, our excess leachate also needs to be treated as well.

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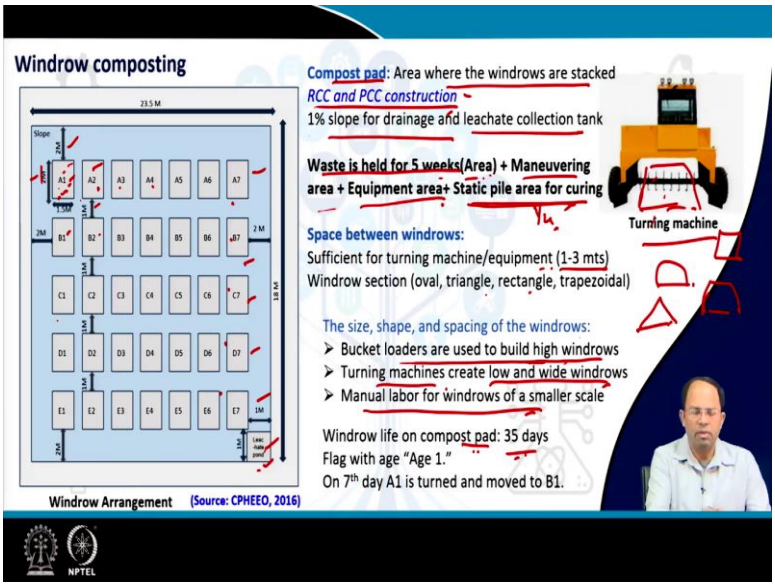

Now, we have talked about tipping areas, pre-sorting areas and all these things, then we have said that we required a compost pad and then that is curing pad. So, the compost pad is the area where windrow are stacked, like over here in this particular area you can see this is the leachate pond and this is where the windrows are stacked. Each windrow is given a name or a flag which says A1, A2, A3, A4 and A5 and so on. So, for 7 days you can see that 7 windrows are created.

Now, starting from 14, 8 day to 14 day A1 is brought to B1, A2 is brought to B2 and so, onwards. And new waste that comes in on day for 7 that becomes A1, A2, A3 in this way what happens? We have… We keep track on which compost is at which age group and we know that which batch has reached which stage of maturity and accordingly we can track the entire composting process, and this transferring from A1 to B1 actually helps in trance you know this breaking up of this garbage and that is also one form of turning you can say.

So, that means the turning is done via picking up this garbage from here and putting it back over here. So, automatically the rest is done. Now, turning could be also done like with bucket loaders like we I saw I showed you that image in the last slide. Similarly, we cannot turning machines like this, if the garbage is fixed, and it is over here, then this just rolls over the garbage and then it can break the garbage over in that location itself. So, this is our turning machine works.

So, this particular compost pad is made of RCC and PCC construction, reinforced cement, concrete and plain cement concrete construction, why? Because this is a area where all these machines will operate the garbage is there to decompose. So, we should not allow it to mix with soil and so on and it has to be cleaned at certain intervals.

So, one per this entire pad is given a 1 percent slope which helps in the drainage through of course, some drains and this underground you know bottom drains you can say from the surface and then leachate is collected in this kind of a leachate pond for further treatment or even for reuse or spraying this leachate as moisture for the garbage.

Waste is held for 5 weeks roughly. Then, so, accordingly we have to determine the area that is required, based on the amount of garbage that comes in, manuring area for you know this for people or for the vehicles equipment area static pile area for curing after you know this compost pad it goes to the curing pad. So, this pile area for curing is also required. So, as I told earlier, this is 1 foot of the actual compost pad.

So, this kind of area has to be probably, we have to provide. So, this gives you an idea about how much gap is between the different piles around 1.5 meter, the size of the windrows you can see 2 meter by 2 meter or 2 meter by 1.5 meter, the height is also 2.5 meter and so on, it depends on what sort of equipment you are using.

So, space between windrow should be sufficient for turning machine or any other kind of equipment something around 1 to 3 meters, windrow section could be oval, triangle, rectangle, trapezoidal, so this mounts that you create could be oval, it could be triangular, it could be trapezoidal, and even rectangular. So, it depends on what sort of machines you are using for creating this kind of mounts.

The size, shape and spacing of windrows depends on bucket loaders used to build or turning machines, and so on. So, if you are using bucket loaders, you can build very high windrows because you can leave the garbage and put it, turning machines cannot leave they just you

know turn the garbage so these are low and wide windrows, manual labour, usually in smaller scale operation we can go with manual labour as well.

So, usually this compost remains in the compost pad for around 35 days, which is around 5 weeks roughly. So, you can see that 1, 2, 3, 4, 5 these are the 5 weeks first week, second week, third week, fourth week, fifth week, that is how A1 becomes B1 then becomes C1 in the different weeks and eventually we have got the final compost.

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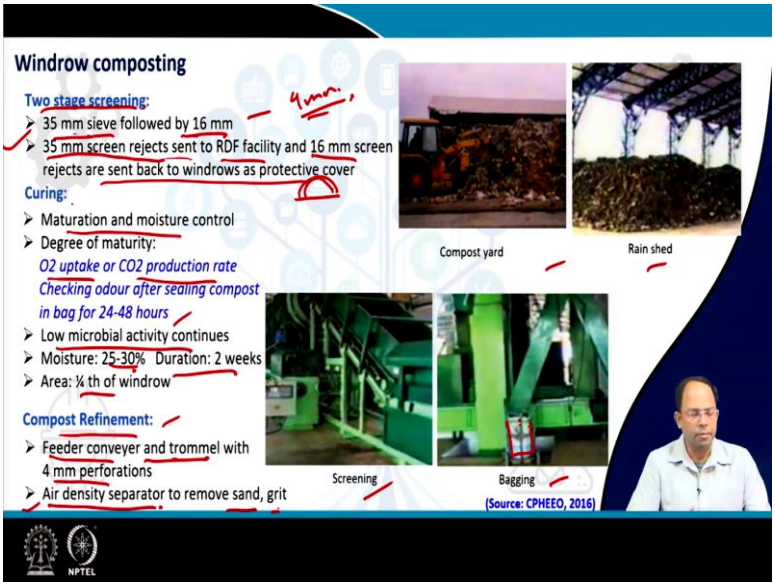

Then once the basic composting process is over, we do a screening of the composite as we have learned earlier, here you can see that 35 millimetres sieve and a 60 millimetres sieve is utilized one after another and once the compost is done, we can use a 4 millimetres sieve for the final you know cure compost is sent through a 4 millimetre sieve before it is bagged.

So, initially we do a 3 millimetre sieve when followed by a 60 millimetre sieve, that rejects from 3 millimetre 35 millimetre screen rejects is sent to RDF facility and then 16 millimetre screen rejects are sent back to the windrows as protected cover or insulation of the windrow at the top. So, this is the you know the pre-screening process before the actual curing happens.

Once the screening is over, then we leave the compost for curing, so we allow the compost to mature and the moisture also returns to the standard values of 25 percent around 20 percent, 25 to 30 percent. We live it for around 2 weeks, and one it takes one forth of the windrow size as we told earlier, and here the microbial activity is considerably low.

And what we need to check at the end is? What is the oxygen uptake of this particular compost and the CO2 production rate if these are low, then of course our manure is ready. The other way to check it is to seal the compost in a bag leave it for 48 hours, 24 to 48 hours and see if it is still smelling or odour is coming. If odour is not coming, that means that compost is matured, it is ready for further use.

Finally compost once the final compost is matured and it is ready, then we can refine the compost by sending it through a 4 millimetre screen, it could be a straw must kind of it could be a feeder conveyor with a trommel screen which goes to 4 millimetre perforations. So, what we are removing is sand and greet and all these things could be removed via a density separator as well. So, these are the different mechanical system that we have learned about earlier. So, this could be utilized to get very pure compost which will be sold.

So, over here you can see some majors of the compost yard range shade, how it looks like. This is the screening area where the compost is screened where this conveyor belt and this is where the bagging is finally happening in these bags. So, this is how our overall compost plant looks like.

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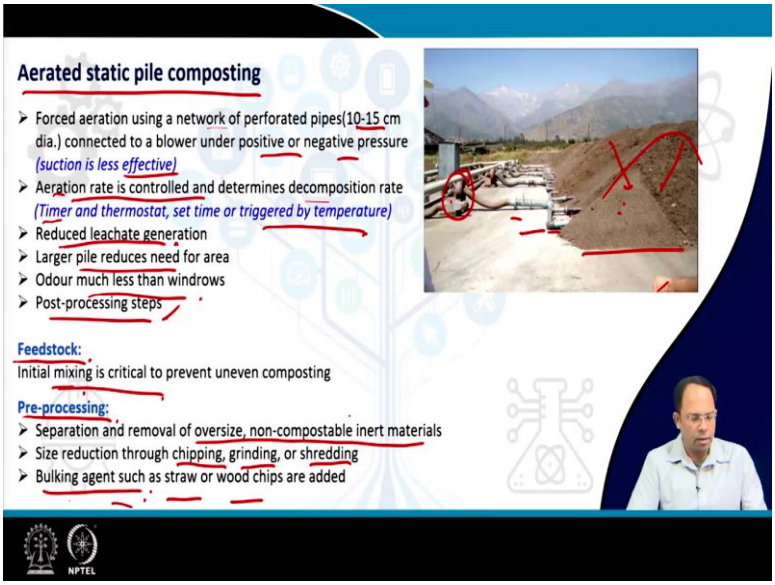

They are coming to a aerated static pile composting. So, in one way we can say it is also a windrow composting, but instead of a turning machine or a turning schedule what we do is? It is a static pile that is we do not turn it but we put this we it is an aerated static pile that means we put air inside these piles, so you can see the compost with this kind of pipes which are over here.

So, what is here? This is a perforated pipe, this pipe is a 10 to 15-centimetre diameter pipe, it is a network or pipe is below the compost, and it is connected to a blower which is over here, this is the blower and this blower can either stuck in the air or it can push air, so either it is positive or negative pressure.

So, when you suck in the air of course, it sucks the air from the (())(12:38) through the garbage, so automatically air will get inside and eventually reads the pipes and from there it goes comes inside but because it is the process is sucking process of course its effectiveness is much less because it has to be done at a very slow sucking process or very negative pressure has to be created lower negative pressure.

So, automatically air goes in but it cannot be done very fast then compost will come inside. But instead the aeration processes, when we are doing positive pressure we are pushing here it could be done at a much faster pace, the aeration rate is controlled or the way this particular blower will operate, will be controlled and determined based on the decomposition rate of the compost and this could be controlled by a thermostat that means there is a temperature sensor inside, it checks what temperature it is, when temperature reaches a certain amount, then we start the aeration or there is or it could be based on a timer based system, that is after a certain time periods, this particular blower will operate or if it is it could be triggered by temperature that means when the temperature is this then the blower will start operating.

So, this kind of system results, aerated system results in lower leachate generation compared to the other one or more larger pile is could be created more high pile could be created as you can see over here that means your total area required to be less, odour is much less because we are using aeration and post processing steps also needs to be there, why?

Because this kind of pile is not broken up. So, you will see a lot of large particles remaining at the end of the composting process. So that means there has to be post processing to remove these larger particles and then either put it back into composting process or send it to RDF facility and so on.

So, for feedstock for this aerated aesthetic pile. This initial mixing is critical because usually we should not put into large material over here, smaller particles and all should be put up because this is a static pile we are not going to break it up. So, this initial mixing is important and if required we have to put in some amount of bulking agents such as your straws, woodchips and so on, so that it creates adequate gaps in the compost so that air can pass through. So, that is why bulking agent is added and this in the pre-processing stages, we will

add these bulking agents and sometimes we can you know, as we say that oversize non-compostable inert materials are past removed that happens in most composting cases.

But over here we have to be very careful that oversize materials do not remain, organic matter even should not be remaining and if required, we have to chip them grind them or shred them, we have as I showed you, I made earlier where people put the garbage inside a shredder machine it will create a smaller size components which is eventually put got this kind of composting.

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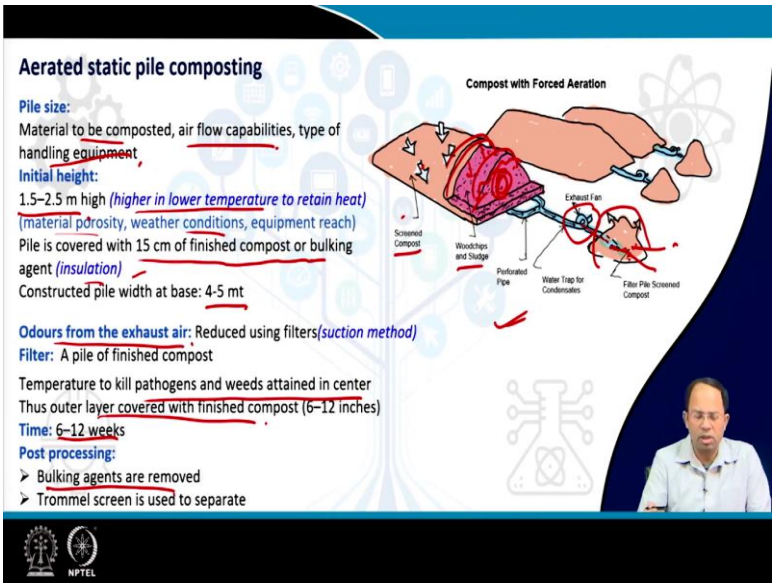

Now, this is how it looks like the pile size is like this, it is covered by a compost layer, which creates the insulation and this compost is mixed with woodchip and all this and perforated piles this is the exhaust fan. And at the end there is a pile of compost which is kept and if you are sucking the air out, then the suck air is sent via this compost heap, this act as a filter and this filter will make sure that the odour is not there, that means when you pass the extracted air through this heap, the order will remove will get removed. So, this is how this aerated static pile looks like.

So, the pile says depends on what kind of airflow capability we have got, what type of handling equipment we have got and what kind of material is being composted, the height is around 1.5 to 2.5 meter and it depends on material porosity, weather conditions equipment reach all this plays a role in determining to up to… What height it will create this kind of piles and sometimes we have to make higher height compost, so that in case of lower temperature and all we want to retain the heat so in that case, we can create the pile size which is higher in size.

The base of the pile is around 4 to 5 meters and it is covered with a 15-centimetre finished compost or bulking which I insulation cover which is either made of finished compost or bulking agents and this does insulation from outside atmosphere. So, odours from exhaust air could be filtered using a compost and then we make sure that temperature to kill pathogens and weeds are attained.

But problem is even though the central part is heated because it is static pile we are not mixing it, but at the periphery heat may not reach that is why the insulation actually helps in, spreading the heat and also, we are putting compost at the end. So, that also helps in more decomposition at the outside layers. So, that is how this outside layer of compost is actually beneficial in case of static piles.

So, time taken is 6 to 12 weeks and post processing once this is done, we have to remove the bulking agents because we are mixing lots of bulking agents because it is a static process, but the compost cannot go with this bulking agent. So, we have to remove these bulking agents from this final compost and trommel screens can be used to do this kind of separation.

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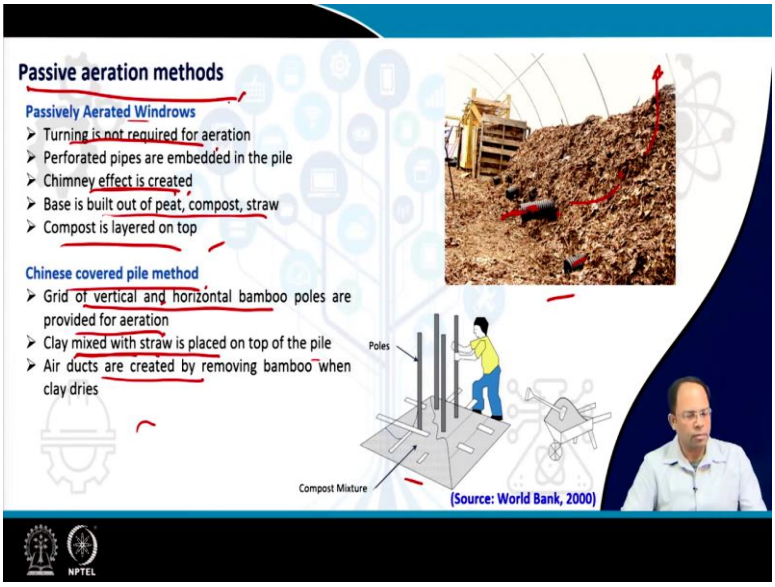

Then, there are some passivation aeration methods which are also utilized, as you can see over here there are pipes which are perforated and where we do not do turning, but the perforated pipes are put in the compost in such a way so that chimney effect is created that means hot air rises upwards. So, hot air enters from below the air enters from below gets heated inside because the of the decomposition that is going on and the heat that is produced then this hot air rises and it leaves from the top.

So, this kind of chimney effect is created so it is a passively edited windrow and bass is built out of peat, compost and straw This allows drainage to happen and also allows some amount of aeration as well. And compost is layered on the top. So, that the same reasons we can create insulation and so on.

Now, a variant of this particular method is the Chinese covered pile method, where instead of using this kind of pipes, what this method says is, we cover the entire you know this compost with a clay mixed with straw is placed on top of the pile. So, that means this clay mix with straw provides that insulation cover yet then agree agreed a vertical and horizontal bamboo poles are provided inside this particular pile.

And this, what we do is once a clay dries up we will remove these poles and this creates air ducts when we remove these bamboo poles and this creates the aeration that is required for this particular pile. So, here we are not putting piles but instead bamboos are put in and then removed so that those air channels are created. So, which air can go inside this particular pile. So, this is called as passive aeration methods.

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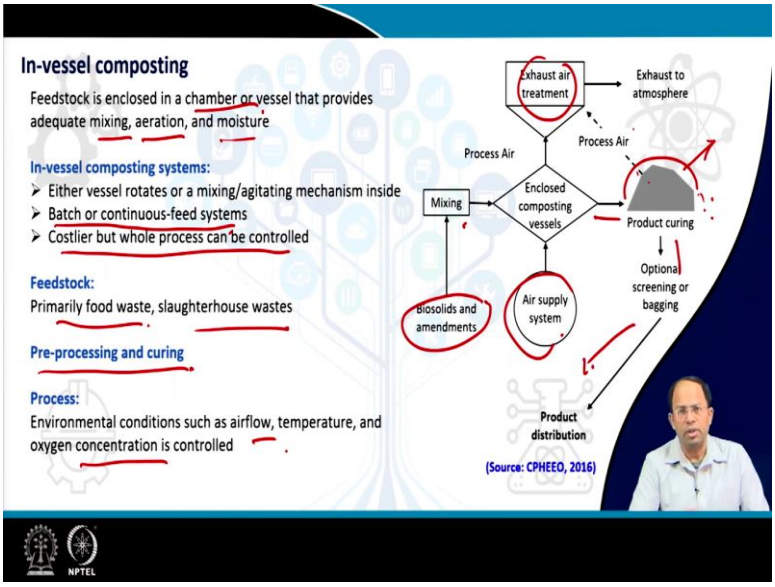

When we come to in vessel composting, so, this is where as we discussed earlier that in in vessel composting not only food waste but also slaughterhouse waste could be also added. Now, in waste kill composting the process itself as you can understand it is not open to atmosphere we use certain sorts of chambers or vessels where we do the composting and this chambers or vessels are responsible for both mixing of the waste, aeration of the waste, as well as providing moisture.

And this could be achieved this entire mixing and all these things could be achieved by either the vessel rotates or the vessel remains fixed inside there is a mechanism which rotates the waste and, breaks the waste at certain intervals. So, some amount and then it introduces air inside and moisture inside and this kind of systems could be can be operated and this could be inside even some certain covered areas or so on.

So, definitely it is a costlier system, but the benefit is all the things like temperature, this airflow and oxygen concentration, all these parameters could be controlled to our desired levels. So, that will ensure what sort of final compost will come out. So, it is costly, but at the same point of time, we can achieve desired you know, quality of the compost as an accord by varying the different parameters of the composting process.

Now, pre-processing and curing is required before we put the waste inside this vessel as well as the it could be a batch or continuous feed system that means the vessel could be designed in such a way so that continuously we keep on adding waste and it continuously gives out compost on the other end or it could be like we put in a group of waste limit for some time and then we take it out the compost and then again we put in another new fresh batch of waste.

So, this is where it shows we bio-solids and amendments are first put inside it is mixed, then air is supplied and exhaust air is comes out which needs to be treated and then the final product is over comes out over here which has to be finally cured and after cured it is bagged and then goes into distribution, whereas after curing whatever gases comes out, it could be allowed to go to the atmosphere or we can even collect it and then treat it the exhaust air could be treated, so that before it is exhausted to the atmosphere.

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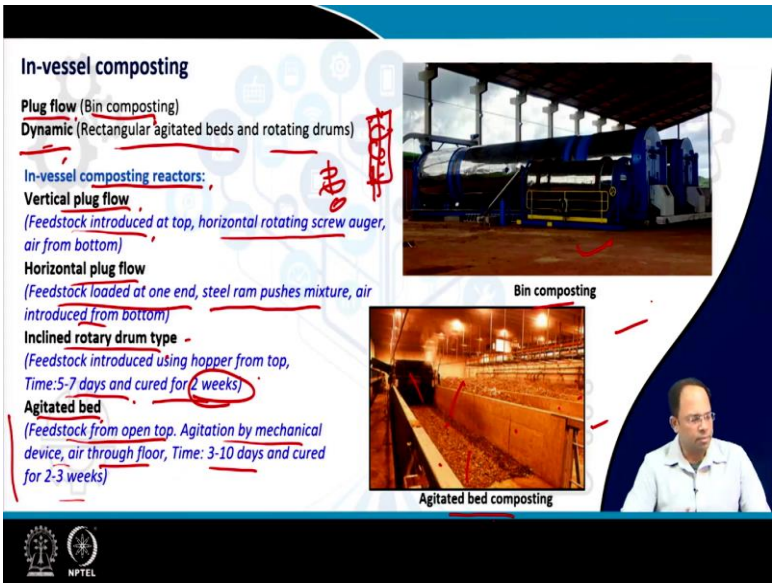

And this is how it looks this has bin composting, these are large bins you can see in the image and over here this is called a agitated bed composting I will come to that. So, primarily there are two kinds of system one is a plug flow system, which is the beam composting system. The other is a dynamic system, dynamic system could be rectangular agitated beds with rotating drums.

So, it is a rectangular bed series of beds are there and there is a rotating drum inside which rolls over this garbage and it breaks the garbage. So, over here and this bed is also agitated. So, it does not allow the compost to be stable and automatically the entire atmosphere is controlled inside this particular chamber. And in wind composting this entire chamber is you know environmentally controlled. So, that is more you know control system compared to this agitated bed system.

So, these composting reactors are of different kinds there are different kinds of plug flow reactor and different kinds of dynamic reactors. So, the vertical plug flow system, horizontal plug flow system, inclined rotary drum type, agitated bed system so, these are the different kinds of systems that are out there. So, in vertical plug flow obviously this is horizontal you can also have a vertical system where feedstock is introduced at the top there is a horizontal rotating screw auger which is like as rotating arm inside which keeps on rotating inside this vertical system and air is spread from the bottom and that actually helps in a composting process.

Horizontal system feedstock loaded at one end, a steel ramp pushes the mixture air is introduced from the bottom and also exhausted as well. So, that means we push it, we push

the garbage from one side and push and from the other side it comes up incline rotary drum type feedstock introduced using hopper from top, so it is continuous introduction of waste. It takes 5 to 7 days and then eventually cured what 2 weeks so any kind of in vessel composting or any kind of composting requires curing. So, for two weeks we have to cure the compost upgrade concept.

Finally, we have the agitated bed, where pit stop from open is given from the top and agitated by mechanical device air comes through the floors it takes around 3 to 10 days and cure for 2 to 3 weeks. So, these are the different kinds of in vessel composting systems that we can utilize.

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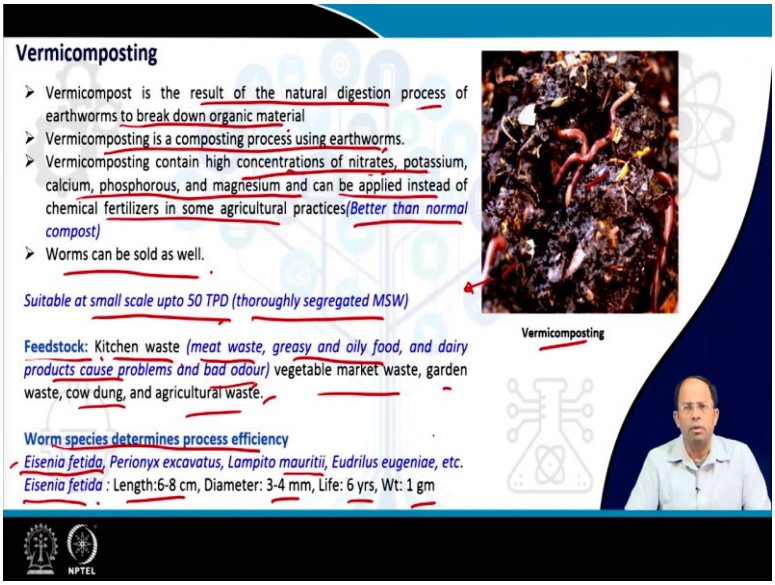

Then we come to Vermicomposting. This is one of the processes which are adopted in decentralized systems particularly and this is usually these are small scale operations but could be large scale as well. And it is as you can understand, you can see the earthworms in the picture. So, these earthworms actually are the ones which are utilized for the composting process. So, vermicompost is the result of the natural digestion process of the earthworms to break down the organic material.

So, these earthworms will consume the organic material and the composting and the material which is the excreta of the earthworm is actually the compost. So, vermicomposting is a composting process using earthworms. This contains high concentration of nitrous, nitrates, potassium, calcium, phosphorus and magnesium and can be applied instead of chemical fertilizers in some agricultural practices, so, it is definitely better than normal compost and it is almost comparable to chemical fertilizer, because we have much higher concentration of

these nutrients, the worms can be also sold once the process is over you can sell the worms as feed for fishes and all this and this is suitable for scale up to 50 tons per day. And usually we use thoroughly segregated municipal solid waste for vermicompost in process.

The feedstock that is provided for vermicomposting is basically kitchen waste, vegetable market waste, garden waste, cow dung and agricultural waste. So, all this organic garbage could be utilized in vermicomposting, but if you provide meat, greasy and oily food and dairy products, this may cause some problems and it will result in bad odour.

The different worm species that are utilized that means earthworms species, some earthworms species are utilized which are more efficient than others. One popular one is this one, this is the red earthworm which is California red earthworm, we call them, this is Eisenia fetida, so this is length around 6 to 8-centimetre diameter 3 to 4-millimetre life of about 6 years and weight of about 1 gram. So, this kind of earthworms are utilized there are other species also, this Perionyx excavatus, then Lampito mauritii. So, all these different species are also utilized.

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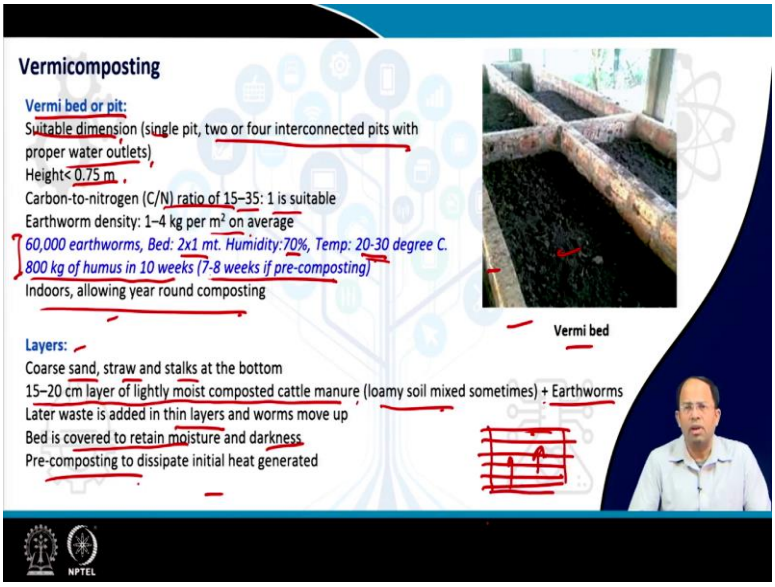

Now, to do vermicomposting, we have to create a Vermi bed or vermi pit. As you can see, this is the vermi bed or pit you want to call it. Now, you have to create it first of all, the dimension would be as per the convenience mostly, it could be a single pit or it could be as per the amount of garbage that has been produced. It is 2 to 4 interconnected pits with proper water outlets, it could be a single pit or it could be an interconnected pits with a drainage network at the bottom, maximum height is 0.75 meter but usually it is much less than that, the

CN ratio is around 15 to 35 and 15 to 35 is to 1 earthworm density is around 1 to 4 kg per meter square on average.

So, roughly to give you an idea 60,000 earthworms in a bed of 2 into 1 meter with humidity 70 percent, temperature 20 to 30-degree, 800 kilogram of humus is created in 10 weeks, if pre-composting is done, then it would be done in even lesser time, which is 7 to 8 weeks. Now, what is pre-composting? Now, pre-composting is, initially we keep the compost for the organic garbage for 2 to 3 days in form of piles or heaps that the initial phase of this bacteria, microbial activity which generates a lot of heat that phase is over.

So, once that phase is over, then we put that compost into the pits. So, that the vermi… The earthworms can act upon it. Now, earthworms operate based below you know this at temperatures which are much lower. So, if I can do pre-composting, then what happens the excess heat like 55-60 degrees centigrade will never happen in this kind of pit. So, that is beneficial. So, that is why it is better to do a pre-composting, but otherwise, it is fine even if you do not do it, it will happen but it will take a little bit more time. This process can happen indoors and can be done year-round. So, in cases areas with lot of rainfall and other issues we can go what can for vermicomposting.

So, the pit is prepared in layers. The bottom layer is coarse sand, straw and stocks at the bottom it allows drainage or leachate drainage and all. So, 15 to 20-centimetre layer is utilized. So, this is utilized as the food for the earthworms and after that what happens we keep on every day when the waste comes in, we keep on adding layers of thin layers of this waste and the warms gradually move upwards.

So, we have got this base layer and then we put layers one above another and gradually the warms move above, bed is covered to retain moisture and darkness and pre-composting to dissipate heat initial heat generated that we have already discussed. So, bed is… So, once the layers are done then at the top, we usually cover the bed to retain moisture and darkness because the ones required darkness and usually that actually helps the process to go more faster.

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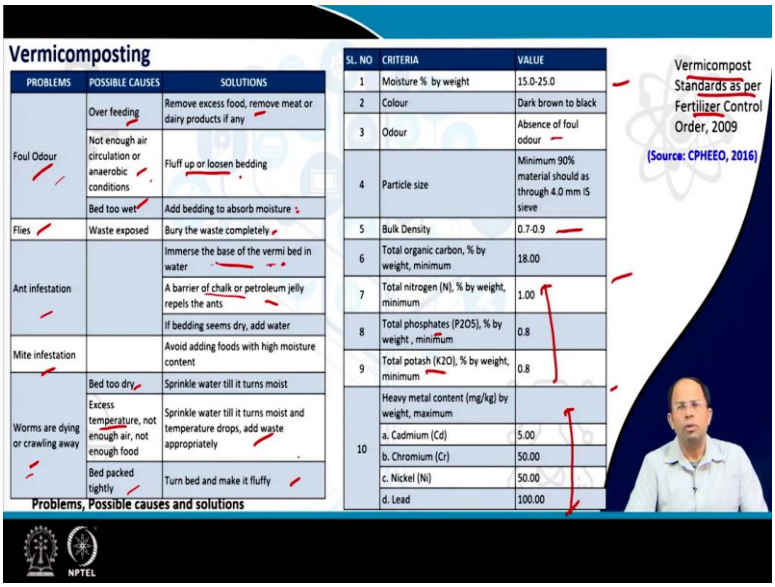

Now, over here you can see the vermicomposting standards given by FCO. So, over here you can see the standards are similar to the standards given by for the for normal compost, but some differences are there you can see the what kind of nitrogen phosphates, potash this is required from vermicompost the bulk density is over here, there should not be any order moisture requirement is given and also heavy metal standards are also given over here.

Now, on this side you can see that during the vermicomposting process, if somebody is practicing vermicomposting, you may see some problems like foul odour creation, flies and mite infestation or you can see the ones that are moving away or coming out of that particular pit. So, these are some of the problems which you have to deal with.

So, in case of foul odour, of course, it may result from either the bed is too wet or there is not too much air anaerobic conditions are there or overfeeding is happening. So, in that case, you have to remove excess food or if it is anaerobic conditions are there then you have to loosen up the bed or if the bed is wet, we have to also add bedding to absorb moisture.

So, that is we have to add certain this base at the bottom so that the bottom base that we talked about earlier that has to be made properly, so that the moisture actually moves out. The flies, if the flies are there, then better to cover it with one layer of compost so that it is the waste is not exposed. Ant infestation we can put barriers or chalk or petroleum jelly around the pit or we can put the pit in water. So, all these things could be done, so that ants does not moves in.

Similarly, for worms the bed may be too dry, or it may be packed too tightly or there may be too much temperature which will help the worm which will make the worms move away. So, that also could be controlled by additional moisture or making the bed more floppy. So, this is how vermicomposting could be controlled.

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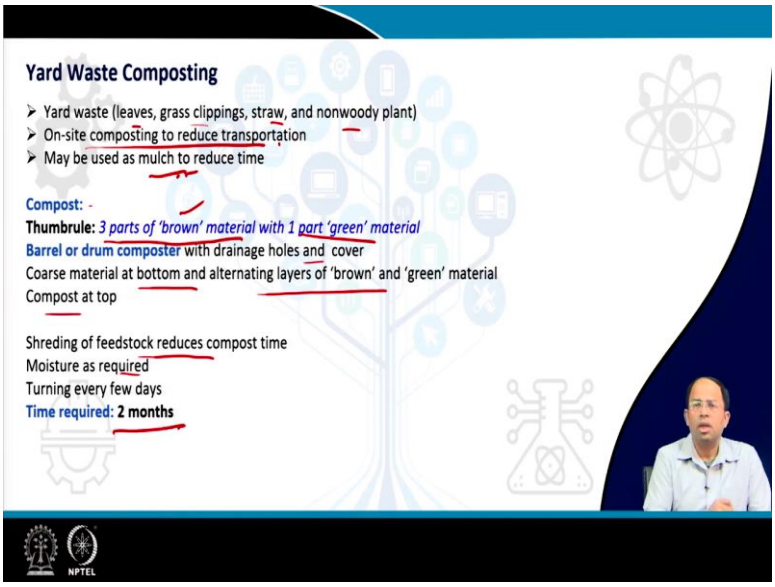

Finally, we come to yard waste composting. So, yard waste composting is like all the garden waste and all these things that are generated that needs to be composted. But sometimes it takes a lot of time to compose this kind of waste. So, instead of making them into waste, we can use them as mulch. So, that means we just spread them over the land and automatically eventually becomes the topsoil.

So, we do not want to do transport, we do not want to transport this waste, we want to do it on site. So, that is why mulching is a better solution. And usually this kind of waste includes leaves, grass clippings, straws, non-woody plants and so on. So, the thumb rule is when we do compost, instead of mulching if I eventually do compost, the thumb rule is to put three pots of brown material with one parts of green material, that means brown material that twigs the branches and all this stuff or green material or the leaves and so on. So, three products of brown material with one pot of green material.

So, barrel or drum composted is utilized. It is just a simple barrel with holes at the bottom and the cover is given so that you know it is not infested by flies or some other kinds of material, other kinds of vector borne you know other kinds of vector infestations. Coarse material is provided at the bottom and alternating layers of brown and green material is put at the top and the compost is given at the top again to prevent odour or for preventing infestation of

flies and other varmints. The feedstock is usually shredded before you put it into the compost chamber usually it is shredded. This will reduce the compost time, a moisture is added as required and tanning is done every few days, total time required for compost production is around 2 months.

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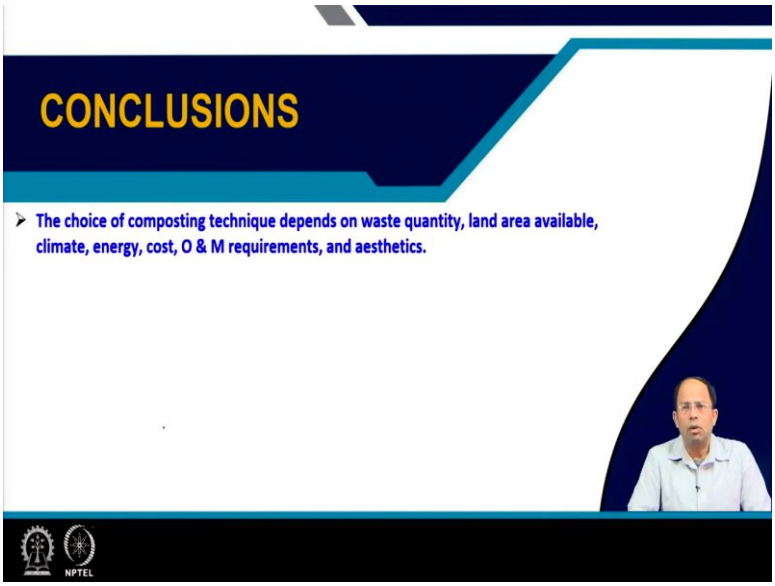

So, these are some of the references that you can study. That to conclude, the choice of composting technique depends on the waste quantity, land area available, climate, energy, cost, operation maintenance requirements and aesthetics.